

**REMARKS**

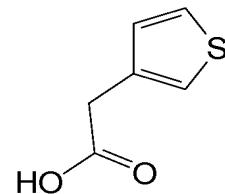
At the outset, the Examiner is thanked for the thorough review and consideration of the pending application. The Final Office Action dated July 20, 2010 has been received and its contents carefully reviewed.

Claim 1 is hereby amended to correct minor informalities. No new matter has been added. Accordingly, claims 1-9 and 11 are currently pending. Reexamination and reconsideration of the pending claims are respectfully requested.

The Office Action rejects claims 1-2, 5-7, and 11 under 35 U.S.C. §103(a) as being obvious over “Nanofabrication of Organic/Inorganic Hybrids of TiO<sub>2</sub> with Substituted Phthalocyanine or Polythiphene” to Ding (*Ding*) in view of “Polymer brushes: surface-immobilized macromolecules” to Zhao (*Zhao*). Applicants respectfully traverse the rejection.

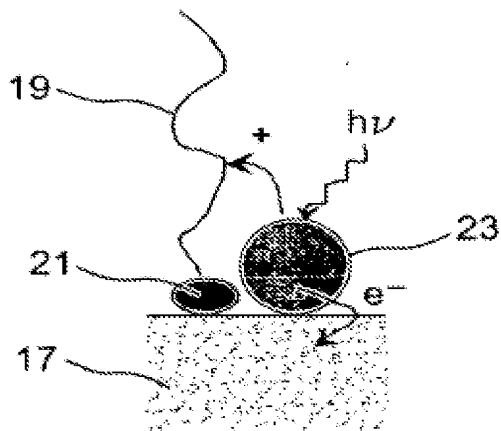
In order to establish *prima facie* obviousness of the claimed invention, all the elements must be taught or suggested by the prior art. The combined teachings of *Ding* and *Zhao* fail to teach each and every element of claims 1-2, 5-7 and 11, and thus, cannot render these claims obvious.

Claim 1 recites “a step in which said substrate is functionalized by chemical grafting of one or more compounds containing at least one group that can be polymerized with one or more precursors of an electrically conducting polymer and at least one group able to be chemically grafted onto said substrate, the one or more compounds are brought into contact with the substrate, and the one or more compounds are grafted to said substrate; a step in which said substrate thus functionalized is impregnated with a solution containing said precursor(s); and a step in which said precursor or precursors are polymerized to obtain polymers grafted to said substrate through the one or more compounds grafted to said substrate.” The present application



further provides that, for example, a compound of the following formula: (the one or more compounds in claim 1) was grafted “onto the surface of the wall of a pore of the porous oxide ceramic.” *Specification*, page 29, lines 25-29. “[T]he oxide layer thus functionalized was immersed in a 0.1 M alkylthiophene solution [said precursor in claim 1] in

chloroform. A 0.3 M iron chloride ( $\text{FeCl}_3$ ) solution was then introduced so as to initiate the polymerization.” *Specification*, page 30, lines 22-26. Figure 2 (reproduced below) shows an enlargement of a photovoltaic cell of the present invention. In Figure 2, reference 17 denotes a surface of wall of a pore of the porous oxide ceramic (the porous oxide ceramic of claim 1), reference 21 denotes a compound (the one or more compounds of claim 1), and reference 19 denotes an electrically conducting polymer (the polymer formed from precursors and grafted to the substrate in claim 1).



**FIG. 2**

*Ding* fails to teach or suggest the above-recited elements of claim 1. The Office Action alleges that “*Ding* teaches ... chemical grafting of one or more compounds containing at least one group (carboxylic groups, sulfonic acid group-section I, ¶3) that can be polymerized with one or more precursors of an electrically conducting polymer (PTAA - section I, ¶3).” *Office Action*, page 3. Section I, ¶3 of *Ding* is reproduced below.

In this article, we present two methods of preparation for ordered ultrathin films of substituted Pc- or PTh-sensitized TiO<sub>2</sub> nanoparticles. Based on these methods, the most efficient surface area of TiO<sub>2</sub> nanoparticles can be coated by Pc molecules or conducting PThs. One method is to cap TiO<sub>2</sub> colloidal nanoparticles with copper phthalocyanine-tetrasulfonic acid (CuTsPc) molecules and then deposit them onto an electrode by a layer-by-layer (LBL) technique. Another approach is to use a titanium alkoxide that reacts directly with poly(thiophene-3-acetic acid) (PTAA) that has appropriate carboxylic groups, thus providing covalent linkages between the organic phase and the inorganic network. Whereas composition, thickness, and orientation of each layer in LBL films can be manipulated at the molecular level,<sup>20–22</sup> a new route for the formation of ordered dye- or conducting polymer-sensitized TiO<sub>2</sub> structures is provided.

According to *Ding*, the sensitized TiO<sub>2</sub> nanoparticles are prepared by (1) cap TiO<sub>2</sub> with CuTsPc, or (2) reacting titanium alkoxide with PTAA.

In addition, the Office Action admits that “Ding is silent to a step in which the substrate thus functionalized being impregnated with a solution containing the precursor(s); and a step in which the precursor(s) are polymerized.” *Office Action*, page 3.

Therefore, the Examiner appears to allege that CuTsPc or PTAA reads on the one or more compounds of claim 1. The Examiner then further alleges that “it would have been obvious to one of ordinary skill in the art at the time of the invention to use the ‘grafting from’ method of Zhao in Ding because ‘grafting from’ decreases the amount of steric hindrance because the precursor (monomers) are smaller molecules than polymers and can readily reach the substrate to link (Zhao: page 695) especially in light of the fact that Ding teaches that increased density of conducting polymer maximizes efficiency (section 1, ¶2).” *Office Action*, page 4.

The Examiner’s reasoning is flawed. Applicants respectfully disagree. *Zhao* does not cure the deficiency of *Ding*.

First, *Zhao* does not cure the deficiency of *Ding*. *Zhao* does not deal with the field of pn-semiconductor, and does not provide a solution to the problem of interpenetration of the n-

semiconductor region and the p-semiconductor region. Instead, *Zhao* generally describes polymer brushes tethered by one end of a substrate and successively treated with a step of immobilizing on a substrate initiator compounds followed by *in situ* surface initiated polymerization. *Zhao* discloses a method that allows an increase in grafting density, but *Zhao* does not deal with the interpenetration of a polymer in the porosity of an oxide substrate as it is the case of the invention for the pn-semiconductor material. The grafting density of *Zhao* only concerns the grafting density of the surface of a substrate.

Second, if one were to use the “grafting from” method of *Zhao* in *Ding* and to graft polymer to the sensitized TiO<sub>2</sub> nanoparticles of *Ding*, it would yield unsatisfactory results. *Ding* emphasizes that “[i]t is necessary for Pcs or PThs to be adsorbed onto the nanoparticle surface in a closely packed monolayer for maximum sensitization efficiency” and “we present two methods of preparation for ordered ultrathin films of substituted Pc- or PTh- sensitized TiO<sub>2</sub> nanoparticles.” *Ding*, page 207, emphasis added. Figure 1 also clearly shows that a monolayer of CsTsPc formed on the nanoparticle surface. Grafting a polymer on top of the monolayer will create additional layers of polymer, and thus destroy the monolayer ultrathin films structure.

Third, if one were to use the “grafting from” method of *Zhao* in *Ding* and to prepare the closely packed monolayer and ordered ultrathin films of substituted Pc- or PTh- sensitized TiO<sub>2</sub> nanoparticles, the resulted TiO<sub>2</sub> nanoparticles would still be monolayer.

Accordingly, claim 1 is allowable over the combined teachings of *Ding* and *Zhao*. Claims 2, 5-7, and 11 variously depend from claim 1, and are also allowable for at least the same reasons as claim 1.

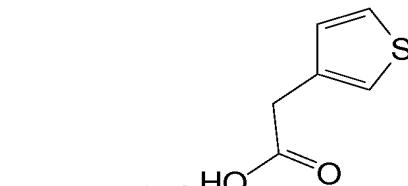
Furthermore, claim 9 recites “the compound used in the functionalization step



satisfies the following formula: HO-C(=O)-CH<sub>2</sub>-C<sub>2</sub>H<sub>4</sub>-S. The precursor used in the impregnation step is an alkylthiophene.” The combined teachings of *Ding* and *Zhao* also fails to teach or suggest these element of claim 9. The Examiner states “modified Ding teaches that the porous oxide ceramic substrate is TiO<sub>2</sub> chemically grafted by thiophone-3-acetic acid (if the polymer directly bonds to the substrate then the link between the substrate and the polymer less one unit will be a

monomer of the polymer which is thiophene-3-acetic acid) to an alkylthiophene (remainder of the PTAA) (Figure 1).” *Office Action*, page 4.

Again, the Examiner’s reasoning is flawed. Applicants respectfully disagree. Claim 9 depends from claim 1, which recites “**a method** of preparing a pn-semiconductor material comprising an n-type region and a p-type region.” Claim 9 specifically requires that the



compound of HO and alkylthiophene be used in the **method**. The Examiner discussed “the link between the substrate and the polymer,” but this link is irrelevant to the above-recited elements in the method claims. The Examiner failed to show that the combined teaching of *Ding* and *Zhao* teaches or suggests all the elements of claim 9 (the specific compound and alkylthiophene used in the method). Accordingly, claim 9 is allowable over the combined teachings of *Ding* and *Zhao* for this additional reason.

Applicants, therefore, respectfully request withdrawal of the rejection of claims 1-2, 5-7, and 11.

The Office Action rejects claims 3-4 and 11 under 35 U.S.C. §103(a) as being over *Ding* and *Zhao* and further in view of “A low cost, high efficiency solar cell based on dye sensitized colloidal TiO<sub>2</sub> films” to O’regan (*O’regan*). Applicants respectfully traverse the rejection.

Claims 3, 4, and 11 variously depend from claim 1 and incorporate all the elements of claim 1. As discussed, the combined teaching of *Ding* and *Zhao* fails to teach or suggest at least the above-recited elements of claim 1. *O’regan* does cure the deficiency of *Ding* and *Zhao*. In fact, the Office Action only cites *O’regan* for disclosing that the nanoparticles are mesoporous. *Office Action*, page 5. Accordingly, claim 1 and its dependent claims 3, 4, and 11 are allowable over the combined teaching of *Ding*, *Zhao*, and *O’regan*. Applicants, therefore, respectfully request withdrawal of the rejection of claims 3, 4, and 11.

The application is in condition for allowance and early, favorable action is respectfully solicited. If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at (202) 496-

7500 to discuss the steps necessary for placing the application in condition for allowance. All correspondence should continue to be sent to the below-listed address.

If these papers are not considered timely filed by the Patent and Trademark Office, then a petition is hereby made under 37 C.F.R. §1.136, and any additional fees required under 37 C.F.R. §1.136 for any necessary extension of time, or any other fees required to complete the filing of this response, may be charged to Deposit Account No. 50-0911. Please credit any overpayment to deposit Account No. 50-0911. A duplicate copy of this sheet is enclosed.

Dated: November 12, 2010

Respectfully submitted,

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